

09/807158

Practitioner's Docket No. U013268-7

JC08 Rec'd PCT/PTO 09 APR 2001

Optional Customer No. Bar Code



00140

PATENT TRADEMARK OFFICE

CHAPTER II

**TRANSMITTAL LETTER  
TO THE UNITED STATES ELECTED OFFICE (EO/US)**

**(ENTRY INTO U.S. NATIONAL PHASE UNDER CHAPTER II)**

PCT/DE99/03204	5 OCTOBER 1999	9 OCTOBER 1998
INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED

**A COMBINED EARTH-STAR SENSOR SYSTEM AND A METHOD FOR DETERMINING THE ORBIT AND ATTITUDE OF SPACE VEHICLES**

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TITLE OF INVENTION

1. HERMANN DIEHL
2. WILLI PLATZ
3. HELMUT ZINNER
4. EVELYNE GOTTZEIN

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APPLICANT(S)

**Box PCT**  
**Assistant Commissioner for Patents**  
**Washington D.C. 20231**  
**ATTENTION: EO/US**

**CERTIFICATION UNDER 37 C.F.R. 1.10\***  
*(Express Mail label number is mandatory.)*  
*(Express Mail certification is optional.)*

I hereby certify that this correspondence and the documents referred to as attached therein are being deposited with the United States Postal Service on this date April 9, 2001, in an envelope as "Express Mail Post Office to Addressee," Mailing Label Number EL728212199US, Addressed to the: Assistant Commissioner for Patents, Washington, D.C. 20231.

CONNIE YANNOTT

*(type or print name of person mailing paper)*

*Connie Yannott*  
 Signature of person mailing paper

**WARNING:** Certificate of mailing (first class) or facsimile transmission procedures of 37 C.F.R. 1.8 cannot be used to obtain a date of mailing or transmission for this correspondence.

**\*WARNING:** Each paper or fee filed by "Express Mail" **must** have the number of the "Express Mail" mailing label placed thereon prior to mailing. 37 C.F.R. 1.10(b).  
 "Since the filing of correspondence under § 1.10 without the Express Mail mailing label thereon is an oversight that can be avoided by the exercise of reasonable care, requests for waiver of this requirement will **not** be granted on petition." Notice of Oct. 24, 1996, 60 Fed. Reg. 56,439, at 56,442.

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**NOTE:** *The completion of those filing requirements that can be made at a time later than 30 months from the priority date results from the Commissioner exercising his judgment under the authority granted under 35 USC 371(d). The filing receipt will show the actual date of receipt of the last item completing the entry into the national phase. See 37 C.F.R. §1.491 which states: "An international application enters the national state when the applicant has filed the documents and fees required by 35 USC 371(c) within the periods set forth in § 1.494 and § 1.495."*

**WARNING:** *Where the items are those which can be submitted to complete the entry of the international application into the national phase are subsequent to 30 months from the priority date the application is still considered to be in the international state and if mailing procedures are utilized to obtain a date the express mail procedure of 37 C.F.R. §1.10 must be used (since international application papers are not covered by an ordinary certificate of mailing - See 37 C.F.R. §1.8.*

**NOTE:** *Documents and fees must be clearly identified as a submission to enter the national state under 35 USC 371 otherwise the submission will be considered as being made under 35 USC 111. 37 C.F.R. § 1.494(f).*

1. Applicant herewith submits to the United States Elected Office (EO/US) the following items under 35 U.S.C. 371:

- a. [X] This express request to immediately begin national examination procedures (35 U.S.C. 371(f)).
- b. [X] The U.S. National Fee (35 U.S.C. 371(c)(1)) and other fees (37 C.F.R. § 1.492) as indicated below:

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## 2. Fees

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CLAIMS FEE	(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) CALCULATIONS
[ ]*	TOTAL CLAIMS	9 - 20 =		x \$ 18.00 =	\$
	INDEPENDENT CLAIMS	2 - 3 =		x \$ 80.00 =	
	MULTIPLE DEPENDENT CLAIM(S) (if applicable) + \$270.00				
BASIC FEE**	<input type="checkbox"/> U.S. PTO WAS INTERNATIONAL PRELIMINARY EXAMINATION AUTHORITY Where an International preliminary examination fee as set forth in § 1.482 has been paid on the international application to the U.S. PTO: <input type="checkbox"/> and the international preliminary examination report states that the criteria of novelty, inventive step (non-obviousness) and industrial activity, as defined in PCT Article 33(2) to (4) have been satisfied for all the claims presented in the application entering the national stage (37 CFR 1.492(a)(4)) ..... \$100.00 <input type="checkbox"/> and the above requirements are not met (37 CFR 1.492(a)(1)) ..... \$690.00  <input checked="" type="checkbox"/> U.S. PTO WAS NOT INTERNATIONAL PRELIMINARY EXAMINATION AUTHORITY Where no international preliminary examination fee as set forth in § 1.482 has been paid to the U.S. PTO, and payment of an international search fee as set forth in § 1.445(a)(2) to the U.S. PTO: <input type="checkbox"/> has been paid (37 CFR 1.492(a)(2)) ..... \$710.00 <input type="checkbox"/> has not been paid (37 CFR 1.492(a)(3)) ..... \$1,000.00 <input checked="" type="checkbox"/> where a search report on the international application has been prepared by the European Patent Office or the Japanese Patent Office (37 CFR 1.492(a)(5)) ..... \$860.00				
	Total of above Calculations				\$60.00
SMALL ENTITY	Reduction by ½ for filing by small entity, if applicable. Affidavit must be filed. (note 37 CFR 1.9, 1.27, 1.28)				-
	Subtotal				\$60.00
	Total National Fee				\$860.00
	Fee for recording the enclosed assignment document \$40.00 (37 CFR 1.21(h)). (See Item 13 below). See attached "ASSIGNMENT COVER SHEET".				
TOTAL	Total Fees enclosed				\$860.00

\*See attached Preliminary Amendment Reducing the Number of Claims.

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- i. ☒ A check in the amount of 860.00 to cover the above fees is enclosed.  
 ii. ☐ Please charge Account No. \_\_\_\_\_ in the amount of \$ \_\_\_\_\_.  
 A duplicate copy of this sheet is enclosed.

**\*\*WARNING:**

*"To avoid abandonment of the application the applicant shall furnish to the United States Patent and Trademark Office not later than the expiration of 30 months from the priority date: \* \* \* (2) the basic national fee (see § 1.492(a)). The 30-month time limit may not be extended." 37 C.F.R. § 1.495(b).*

**WARNING:**

If the translation of the *irregular application* and/or the oath or declaration have not been submitted by the applicant within thirty (30) months from the priority date, such requirements may be met within a time period set by the Office. 37 C.F.R. § 1.495(b)(2). The payment of the surcharge set forth in § 1.492(e) is required as a condition for accepting the oath or declaration later than thirty (30) months after the priority date. The payment of the processing fee set forth in § 1.492(f) is required for acceptance of an English translation later than thirty (30) months after the priority date. Failure to comply with these requirements will result in abandonment of the application. The provisions of § 1.136 apply to the period which is set. Notice of Jan. 3, 1993, 1147 O.G. 29 to 40.

3. [x] A copy of the International application as filed (35 U.S.C. 371(c)(2)):

*NOTE: Section 1.495 (b) was amended to require that the basic national fee and a copy of the international application must be filed with the Office by 30 months from the priority date to avoid abandonment. "The International Bureau normally provides the copy of the international application to the Office in accordance with PCT Article 20. At the same time, the International Bureau notifies applicant of the communication to the Office. In accordance with PCT Rule 47.1, that notice shall be accepted by all designated offices as conclusive evidence that the communication has duly taken place. Thus, if the applicant desires to enter the national stage, the applicant normally need only check to be sure the notice from the International Bureau has been received and then pay the basic national fee by 30 months from the priority date." Notice of Jan. 7, 1993, 1147 O.G. 29 to 40, at 35-36. See item 14c below.*

- a. ☒ is transmitted herewith.
- b. ☐ is not required, as the application was filed with the United States Receiving Office.
- c. ☐ has been transmitted
- i. ☐ by the International Bureau.  
Date of mailing of the application (from form PCT/IB/308): \_\_\_\_\_.
- ii. ☐ by applicant on \_\_\_\_\_.  
Date

4. [x] A translation of the International application into the English language (35 U.S.C. 371(c)(2)):
- a. [x] is transmitted herewith.
- b. [ ] is not required as the application was filed in English.
- c. [ ] was previously transmitted by applicant on \_\_\_\_\_.
- d. [ ] will follow.
- Date

NOTE: The Notice of January 7, 1993 points out that 37 C.F.R. § 1.495(a) was amended to clarify the existing and continuing practice that PCT Article 19 amendments must be submitted by 30 months from the priority date and this deadline may not be extended. The Notice further advises that: "The failure to do so will not result in loss of the subject matter of the PCT Article 19 amendments. Applicant may submit that subject matter in a preliminary amendment filed under section 1.121. In many cases, filing an amendment under section 1.121 is preferable since grammatical or idiomatic errors may be corrected." 1147 O.G. 29-40, at 36.

6. [x] A translation of the amendments to the claims under PCT Article 19 (38 U.S.C. 371(c)(3)):

- a. ☐ is transmitted herewith.
- b. ☐ is not required as the amendments were made in the English language.
- c. ☒ has not been transmitted for reasons indicated at point 5(c) above.

7. [x] A copy of the international examination report (PCT/IPEA/409)  
 [x] is transmitted herewith.  
 [ ] is not required as the application was filed with the United States Receiving  
 Office.

8. [x] Annex(es) to the international preliminary examination report
- a. [x] is/are transmitted herewith.
- b. [ ] is/are not required as the application was filed with the United States Receiving Office.

9. [x] A translation of the annexes to the international preliminary examination report
- a. [x] is transmitted herewith.
- b. [ ] is not required as the annexes are in the English language.

10. ☒ An oath or declaration of the inventor (35 U.S.C. 371(c)(4)) complying with 35 U.S.C. 115
- a. ☐ was previously submitted by applicant on \_\_\_\_\_.  
Date
- b. ☐ is submitted herewith, and such oath or declaration
- i. ☐ is attached to the application.
- ii. ☐ identifies the application and any amendments under PCT Article 19 that were transmitted as stated in points 3(b) or 3(c) and 5(b); and states that they were reviewed by the inventor as required by 37 C.F.R. 1.70.
- c. ☒ will follow.

Other document(s) or information included:

11. ☒ An International Search Report (PCT/ISA/210) or Declaration under PCT Article 17(2)(a):
- a. ☐ is transmitted herewith.
- b. ☒ has been transmitted by the International Bureau.  
Date of mailing (from form PCT/IB/308): 20 APRIL 2000.
- c. ☐ is not required, as the application was searched by the United States International Searching Authority.
- d. ☐ will be transmitted promptly upon request.
- e. ☐ has been submitted by applicant on \_\_\_\_\_.  
Date
12. ☒ An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98:
- a. ☒ is transmitted herewith.  
Also transmitted herewith is/are:  
☒ Form PTO-1449 (PTO/SB/08A and 08B).  
☒ Copies of citations listed.
- b. ☐ will be transmitted within THREE MONTHS of the date of submission of requirements under 35 U.S.C. 371(c).
- c. ☐ was previously submitted by applicant on \_\_\_\_\_.  
Date
13. ☐ An assignment document is transmitted herewith for recording.

A separate ☐ "COVER SHEET FOR ASSIGNMENT (DOCUMENT) ACCOMPANYING NEW PATENT APPLICATION" or ☐ FORM PTO 1595 is also attached.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

14. [x] Additional documents:
- a. [x] Copy of request (PCT/RO/101)
  - b. [x] International Publication No. WO 00/22381
    - i. [ ] Specification, claims and drawing
    - ii. [x] Front page only
  - c. [ ] Preliminary amendment (37 C.F.R. § 1.121)
  - d. [x] Other

4 PAGES OF DRAWINGS; FORM PCT/IB/301; FORM PCT/IB/304  
FORM PCT/IB/306; FORM PCT/IB/308; FORM PCT/IPEA/401;  
FORM PCT/IPEA/416

15. [x] The above checked items are being transmitted
- a. [x] before 30 months from any claimed priority date.
  - b. [ ] after 30 months.
16. [ ] Certain requirements under 35 U.S.C. 371 were previously submitted by the applicant on \_\_\_\_\_, namely:
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_

#### AUTHORIZATION TO CHARGE ADDITIONAL FEES

**WARNING:** *Accurately count claims, especially multiple dependent claims, to avoid unexpected high charges if extra claims are authorized.*

**NOTE:** *"A written request may be submitted in an application that is an authorization to treat any concurrent or future reply, requiring a petition for an extension of time under this paragraph for its timely submission, as incorporating a petition for extension of time for the appropriate length of time. An authorization to charge all required fees, fees under § 1.17, or all required extension of time fees will be treated as a constructive petition for an extension of time in any concurrent or future reply requiring a petition for an extension of time under this paragraph for its timely submission. Submission of the fee set forth in § 1.17(a) will also be treated as a constructive petition for an extension of time in any concurrent reply requiring a petition for an extension of time under this paragraph for its timely submission." 37 C.F.R. § 1.136(a)(3).*

**NOTE:** *"Amounts of twenty-five dollars or less will not be returned unless specifically requested within a reasonable time, nor will the payer be notified of such amounts; amounts over twenty-five dollars may be returned by check or, if requested, by credit to a deposit account." 37 C.F.R. § 1.26(a).*

- [X] The Commissioner is hereby authorized to charge the following additional fees that may be required by this paper and during the entire pendency of this application to Account No. 12-0425.

[X] 37 C.F.R. 1.492(a)(1), (2), (3), and (4) (filing fees)

**WARNING:** *Because failure to pay the national fee within 30 months without extension (37 C.F.R. § 1.495(b)(2)) results in abandonment of the application, it would be best to always check the above box*

[ ] 37 C.F.R. 1.492(b), (c) and (d) (presentation of extra claims)

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only be paid or these claims cancelled by amendment prior to the expiration of the time period set for response by the PTO in any notice of fee deficiency (37 C.F.R. § 1.492(d)), it might be best not to authorize the PTO to charge additional claim fees, except possible when dealing with amendments after final action.

- ☒ 37 C.F.R. 1.17 (application processing fees)
- ☒ 37 C.F.R. 1.17(a)(1)-(5)(extension fees pursuant to § 1.136(a).
- ☒ 37 C.F.R. 1.18 (issue fee at or before mailing of Notice of Allowance, pursuant to 37 C.F.R. 1.311(b))

NOTE: Where an authorization to charge the issue fee to a deposit account has been filed before the mailing of a Notice of Allowance, the issue fee will be automatically charged to the deposit account at the time of mailing the notice of allowance. 37 C.F.R. § 1.311(b).

NOTE: 37 C.F.R. 1.28(b) requires "Notification of any change in loss of entitlement to small entity status must be filed in the application . . . prior to paying, or at the time of paying . . . issue fee." From the wording of 37 C.F.R. § 1.28(b): (a) notification of change of status must be made even if the fee is paid as "other than a small entity" and (b) no notification is required if the change is to another small entity.

- ☐ 37 C.F.R. § 1.492(e) and (f) (surcharge fees for filing the declaration and/or filing an English translation of an International Application later than 30 months after the priority date).



SIGNATURE OF PRACTITIONER

JULIAN H. COHEN

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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Hermann DIEHL, et al

Serial No.: 09/807,158

Group No.:

Filed: April 9, 2001

Examiner.:

For: COMBINED EARTH/STAR SENSOR SYSTEM AND METHOD FOR  
DETERMINING THE ORBIT AND POSITION OF SPACECRAFT

Attorney Docket No.: U 013268-7

Box PCT

Assistant Commissioner for Patents

Washington, D.C. 20231

ATTENTION: EO/US

Sirs:

PRELIMINARY AMENDMENT

Please amend the above application as follows.

IN THE CLAIMS

4. (amended) The sensor system according to claim 1, characterised in that the aperture for the light from the earth is considerably smaller than the aperture for the starlight.

7. (amended) The method according to claim 5, further characterised by model-based tracking of the rim of the earth.

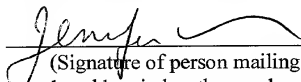
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CERTIFICATE UNDER 37 CFR 1.10

I hereby certify that this paper is being deposited with the United States Postal Service on this date May 15, 2001 in an envelope as "EXPRESS MAIL POST OFFICE TO ADDRESSEE" Mailing Label Number EL728212905 US addressed to the: Assistant Commissioner of Patents and Trademarks, Washington, D.C. 20231

JENNIFER RASHKIN

(Type or print name of person mailing paper)



(Signature of person mailing paper)

NOTE: Each paper or fee referred to as enclosed herein has the number of the "EXPRESS MAIL" mailing label place thereon prior to mailing 37 CFR 1.16(b).

8. (amended) The method according to claim 5, characterised in that a long-wave fraction of the radiation is filtered out and used for determining the rim of the earth.

9. (amended) The method according to claim 5, characterised in that the rim of the earth is determined by fitting earth models.

Please add the following new claims:

10. (new) The sensor system according to claim 2, characterised in that the aperture for the light from the earth is considerably smaller than the aperture for the starlight.

11. (new) The sensor system according to claim 3, characterised in that the aperture for the light from the earth is considerably smaller than the aperture for the starlight.

12. (new) The method according to claim 6, further characterised by model-based tracking of the rim of the earth.

13. (new) The method according to claim 6, characterised in that a long-wave fraction of the radiation is filtered out and used for determining the rim of the earth.

14. (new) The method according to claim 7, characterised in that a long-wave fraction of the radiation is filtered out and used for determining the rim of the earth.

15. (new) The method according to claim 6, characterised in that the rim of the earth is determined by fitting earth models.

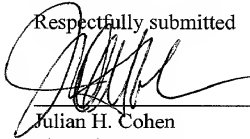
16. (new) The method according to claim 7, characterised in that the rim of the earth is determined by fitting earth models.

17. (new) The method according to claim 8, characterised in that the rim of the earth is determined by fitting earth models

REMARKS

The above amendatory action is taken solely for the purpose of avoiding claim fees that would otherwise accrue due to the presence of multiple dependent claims.

Respectfully submitted

A handwritten signature in black ink, appearing to read 'Julian H. Cohen', written over a horizontal line.

Julian H. Cohen

c/o Ladas & Parry

26 West 61<sup>st</sup> Street

New York, New York 10023

Reg. No.: 20302 (212) 708-1887

MARKED-UP COPY

4. (amended) The sensor system according to claim [one of claims] 1 [to 3], characterised in that the aperture for the light from the earth is considerably smaller than the aperture for the starlight.

7. (amended) The method according to claim 5 [or 6], further characterised by model-based tracking of the rim of the earth.

8. (amended) The method according to claim [one of claims] 5 [to 7], characterised in that a long-wave fraction of the radiation is filtered out and used for determining the rim of the earth.

9. (amended) The method according to claim [one of claims] 5 [to 8], characterised in that the rim of the earth is determined by fitting earth models.

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09 APR 2001

**A combined earth-star sensor system and a method for determining the orbit and attitude of space vehicles**

The invention relates to a combined earth-star sensor system for three-axis attitude determination of satellites in space, as well as a method for determining the orbit and attitude of space vehicles.

For earth-oriented satellites, infrared sensors are presently used to determine roll and pitch angles, while solar sensors are used to determine the yaw angle of the satellite. This solution is associated with the disadvantage of the arrangement of several solar sensor heads used being very expensive, and of the lack of any yaw reference in the case of co-linearity of the earth and the sun. Furthermore, evaluation additionally requires an exact knowledge of the attitude of the satellite on its orbit. Moreover, errors between the measuring axes of solar sensors and earth sensors, e.g. caused by inaccuracies during installation or as a result of thermal influence, can significantly degrade the quality of measurements.

Known star sensors provide a three-axis attitude reference in an inertial system. Here too, earth alignment requires an exact knowledge of the satellite attitude. At present, CCDs are used for such star sensors. Due to their lack of radiation resistance, they are not suitable for use in orbits with substantial radiation load, e.g. for use in geosynchronous missions.

From EP 0 589 387 A1 a combined earth-star sensor system is known which uses a single optical arrangement to carry out both star observation and earth observation in the UV range. To carry out common

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observation, the optical arrangement comprises a wide-angle system incorporating a mirror system. Due to the coinciding directions of observation for earth observation and star observation, the known system is only able to observe stars in proximity to the earth; and due to the sensor being designed with the strong earth radiation in mind, for attitude determination the known system is only able to observe stars of high intensity.

From US 5,189,295 a combined earth-star sensor system for three-axis attitude determination in space is known, with the combined earth-star sensor system comprising separate apertures with different directions of observation and common image pickup devices for the earth sensor and the star sensor. The earth is partially shielded by a screen, so as to allow acquisition of the pole star. There is however a problem that the difference in brightness between the earth and stars has not been taken into account adequately. Consequently, adequate acquisition of the earth and stars is not ensured.

It is thus the object of the invention to provide a combined earth-star sensor system which is not limited in regard to the selection of stars suitable for observation, and which can be produced economically and which allows optimal acquisition of the stars to be observed and the earth. Furthermore, it is the object of the invention to provide a method for determining the orbit and attitude of a space vehicle, said method being more accurate and allowing optimal acquisition of the stars to be observed and the earth, as well as allowing independent on-board operation.

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This object is met by the combined earth-star sensor system according to claim 1 and the method according to claim 5. Further advantageous characteristics, aspects and details of the invention are provided in the dependent claims, the description and the drawings.

The combined earth-star sensor system according to the invention, for three-axis attitude determination of satellites in space comprises separate apertures with different directions of observation and common image pickup devices for the earth sensor and the star sensor. The sensor allows variable control of the exposure time so that integration can be adapted to the difference in brightness of the stars and the earth. Preferably, exposure is always in turn, one frame long and one frame short.

Observation according to the invention, of the earth and the stars with different apertures makes it possible to observe stars of magnitude 5 too. The considerable difference in the intensity of radiation of these stars when compared to earth radiation, can be absorbed by different aperture design and filtering. In spite of concurrent observation of the earth, the detection of the stars is not influenced by the scattered light from the earth, if two apertures are used. The simple design of the system according to the invention can cope with high light intensities while keeping costs low. High light intensity allows the use of economical CMOS image pickup devices.

Preferably the CMOS image pickup devices form a CMOS focal plane array as a focal plane sensor with a dynamic range of up to  $1:10^6$ . It makes possible variable control of the exposure time, so that

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integration can be adapted to the difference in brightness of the stars and the earth.

By using an alternative proposal of two different optical arrangements instead of a common optical arrangement, the wavelength bands used for detection can be optimised independently of each other.

The integrated sensor system according to the invention makes it possible to determine three attitude angles, three angle speeds, and the attitude of the space vehicle. Software control makes it possible to cover different orbits such as geosynchronous orbits, transfer orbits as well as low, middle and elliptical orbits.

The method according to the invention comprises the following steps:

simultaneous imaging of stars and rim of the earth in one focal plane of a sensor system; determining the star attitude in the focal plane; determining the rim of the earth by image processing; determining rates of rotation of the sensor system from the movement of the star image in the focal plane; and calculating the orbit and/or attitude of a space vehicle which carries the sensor system. By alternate adaptation of the exposure time or the integration time of the sensor or of the image pickup device, to the brightness of the stars and the brightness of the earth, even stars which are less bright can be acquired concurrently with the rim of the earth.

With the device and the method, highly accurate information on the orbit and the attitude of the space vehicle or satellite can be obtained concurrently.



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By filtering out or acquiring a long-wave fraction of the radiation, e.g. by means of edge filters, the rim of the earth can be acquired particularly well and with particularly good stability. Additional degrees of freedom can be determined by model based tracking of the rim of the earth.

Further advantages of the invention include a lower mass or possible redundancy because there is no need for further equipment such as for example gyros which were hitherto required for determining the orbit and the attitude. This results in simplified integration and inherent radiation resistance. Orbit determination is possible without the use of GPS, in particular also for near-earth and geostationary satellites. In this way, independent on-board operation can be achieved.

Below, embodiments of the invention are explained in more detail by means of the drawing.

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CLAIMS

1. A combined earth-star sensor system for three-axis attitude determination of satellites in space, with the combined earth-star sensor system (1) comprising separate apertures with different directions of observation and common image pickup devices (4) for the earth sensor and the star sensor, characterised in that the sensor system comprises means for variable control of the exposure time depending on the brightness of the earth and the stars to be observed.
2. The sensor system according to claim 1, characterised in that the earth-star sensor system (1) comprises a common optical arrangement (2) for earth observation and star observation, and a deflection mirror (3) for deviation of the laterally entering light from the earth, to the common optical arrangement (2).
3. The sensor system according to claim 1, characterised in that the earth-star sensor system (1) comprises an optical arrangement (9) for star observation, an optical arrangement (10) for earth observation and a semitranslucent beam splitter (8) for deviating the laterally entering light from the earth and transferring the starlight which enters in longitudinal direction, to the image pickup devices (4).
4. The sensor system according to one of claims 1 to 3, characterised in that the aperture for the light from the earth is considerably smaller than the aperture for the starlight.

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5. A method for simultaneous orbit determination and attitude determination of a space vehicle, characterised by the steps:

- Simultaneous imaging of stars and the rim of the earth in one focal plane of a sensor system;
- Determining the star attitude in the focal plane;
- Determining the rim of the earth by image processing;
- Determining the rates of rotation of the sensor system from the movement of the star image in the focal plane; and
- Calculating the orbit and/or attitude of a space vehicle carrying the sensor system,

characterised in that the exposure time or the integration time of the sensor system is alternately adapted to the difference in brightness of the stars and the earth.

6. The method according to claim 5, characterised in that the evaluation system of the sensor system by means of a star catalogue or similar prior knowledge disregards those areas in the image where the image of the rim of the earth and images of stars are superimposed, thus eliminating disturbing influences concerning the accuracy of determining the rim of the earth in the image.

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7. The method according to claim 5 or 6, further characterised by model-based tracking of the rim of the earth.
8. The method according to one of claims 5 to 7, characterised in that a long-wave fraction of the radiation is filtered out and used for determining the rim of the earth.
9. The method according to one of claims 5 to 8, characterised in that the rim of the earth is determined by fitting earth models.

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Optional Customer No. Bar Code



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PATENT TRADEMARK OFFICE

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COMBINED DECLARATION AND POWER OF ATTORNEY

---

(ORIGINAL, DESIGN, NATIONAL STAGE OF PCT, SUPPLEMENTAL, DIVISIONAL,  
CONTINUATION, OR C-I-P)

---

As a below named inventor, I hereby declare that:

TYPE OF DECLARATION

This declaration is of the following type:

(check one applicable item below)

- ☐ original.  
☐ design.

NOTE: With the exception of a supplemental oath or declaration submitted in a reissue, a supplemental oath or declaration is not treated as an amendment under 37 CFR 1.312 (Amendments after allowance). M.P.E.P. Section 714.16, 7<sup>th</sup> Ed.

- ☐ supplemental.

NOTE: If the declaration is for an International Application being filed as a divisional, continuation or continuation-in-part application, do not check next item; check appropriate one of last three items.

- ☒ national stage of PCT.

NOTE: If one of the following 3 items apply, then complete and also attach ADDED PAGES FOR DIVISIONAL, CONTINUATION OR C-I-P.

NOTE: See 37 C.F.R. Section 1.63(d) (continued prosecution application) for use of a prior nonprovisional application declaration in the continuation or divisional application being filed on behalf of the same or fewer of the inventors named in the prior application.

- ☐ divisional.  
☐ continuation.

NOTE: Where an application discloses and claims subject matter not disclosed in the prior application, or a continuation or divisional application names an inventor not named in the prior application, a continuation-in-part application must be filed under 37 C.F.R. Section 1.53(b) (application filing requirements-nonprovisional application).

- ☐ continuation-in-part (C-I-P).

## INVENTORSHIP IDENTIFICATION

**WARNING:** *If the inventors are each not the inventors of all the claims, an explanation of the facts, including the ownership of all the claims at the time the last claimed invention was made, should be submitted.*

My residence, post office address and citizenship are as stated below, next to my name. I believe that I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter that is claimed, and for which a patent is sought on the invention entitled:

## TITLE OF INVENTION

COMBINED EARTH/STAR SENSOR SYSTEM AND METHOD FOR DETERMINING THE  
ORBIT AND POSITION OF SPACECRAFT

## SPECIFICATION IDENTIFICATION

The specification of which:

(complete (a), (b), or (c))

(a) ☐ is attached hereto.

**NOTE:** *"The following combinations of information supplied in an oath or declaration filed on the application filing date with a specification are acceptable as minimums for identifying a specification and compliance with any one of the items below will be accepted as complying with the identification requirement of 37 C.F.R. Section 1.63:*

*"(1) name of inventor(s), and reference to an attached specification which is both attached to the oath or declaration at the time of execution and submitted with the oath or declaration on filing;*

*"(2) name of inventor(s), and attorney docket number which was on the specification as filed; or*

*"(3) name of inventor(s), and title which was on the specification as filed."*

*Notice of July 13, 1995 (1177 O.G. 60).*

(b) ☐ was filed on \_\_\_\_\_, ☐ as Application No. \_\_\_\_\_  
☐ and was amended on \_\_\_\_\_ (if applicable).

**NOTE:** *Amendments filed after the original papers are deposited with the PTO that contain new matter are not accorded a filing date by being referred to in the declaration. Accordingly, the amendments involved are those filed with the application papers or, in the case of a supplemental declaration, are those amendments claiming matter not encompassed in the original statement of invention or claims. See 37 C.F.R. Section 1.67.*

**NOTE:** *"The following combinations of information supplied in an oath or declaration filed after the filing date are acceptable as minimums for identifying a specification and compliance with any one of the items below will be accepted as complying with the identification requirement of 37 C.F.R. Section 1.63:*

*(A) application number (consisting of the series code and the serial number, e.g., 08/123,456);*

*(B) serial number and filing date;*

*(C) attorney docket number which was on the specification as filed,*

*(D) title which was on the specification as filed and reference to an attached specification which is both attached to the oath or declaration at the time of execution and submitted with the oath or declaration; or*

*(E) title which was on the specification as filed and accompanied by a cover letter accurately identifying the application for which it was intended by either the application number (consisting of the series code and the serial number, e.g., 08/123,456), or serial number and filing date. Absent any statement(s) to the contrary, it will be presumed that the application filed in the PTO is the application which the inventor(s) executed by signing the oath or declaration.*

*M.P.E.P. Section 601.01(a), 7th ed.*

- (c) ☒ was described and claimed in PCT International Application No. PCT/DE99/03204 filed on October 5, 1999 and as amended under PCT Article 19 on \_\_\_\_\_ (if any).

**SUPPLEMENTAL DECLARATION (37 C.F.R. Section 1.67(b))**

*(complete the following where a supplemental declaration is being submitted)*

☐ I hereby declare that the subject matter of the

☐ attached amendment

☐ amendment filed on \_\_\_\_\_.

was part of my/our invention and was invented before the filing date of the original application, above identified, for such invention.

**ACKNOWLEDGMENT OF REVIEW OF PAPERS AND DUTY OF CANDOR**

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information, which is material to patentability as defined in 37, Code of Federal Regulations, Section 1.56,

*(also check the following items, if desired)*

☐ and which is material to the examination of this application, namely, information where there is a substantial likelihood that a reasonable Examiner would consider it important in deciding whether to allow the application to issue as a patent, and

☐ in compliance with this duty, there is attached an information disclosure statement, in accordance with 37 C.F.R. Section 1.98.

**PRIORITY CLAIM (35 U.S.C. Section 119(a)-(d))**

*NOTE: "The claim to priority need be in no special form and may be made by the attorney or agent if the foreign application is referred to in the oath or declaration as required by Section 1.63. The claim for priority and the certified copy of the foreign application specified in 35 U.S.C. Section 119(b) must be filed in the case of an interference (Section 1.630), when necessary to overcome the date of a reference relied upon by the examiner, when specifically required by the examiner, and in all other situations, before the patent is granted. If the claim for priority or the certified copy of the foreign application is filed after the date the issue fee is paid, it must be accompanied by a petition requesting entry and by the fee set forth in Section 1.17(i). If the certified copy is not in the English language, a translation need not be filed except in the case of interference; or when necessary to overcome the date of a reference relied upon by the examiner; or when specifically required by the examiner, in which event an English language translation must be filed together with a statement that the translation of the certified copy is accurate." 37 C.F.R. Section 1.55(a).*

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

(complete (d) or (e))

- (d) ☐ no such applications have been filed.  
(e) ☒ such applications have been filed as follows.

NOTE: Where item (c) is entered above and the International Application which designated the U.S. itself claimed priority check item (e), enter the details below and make the priority claim.

**PRIOR FOREIGN/PCT APPLICATION(S) FILED WITHIN 12 MONTHS  
(6 MONTHS FOR DESIGN) PRIOR TO THIS APPLICATION  
AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. SECTION 119(a)-(d)**

COUNTRY (OR INDICATE IF PCT)	APPLICATION NUMBER	DATE OF FILING DAY, MONTH, YEAR	PRIORITY CLAIMED UNDER 35 USC 119
DE	198 46 690.0	9 October 1998	<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO

**CLAIM FOR BENEFIT OF PRIOR U.S. PROVISIONAL APPLICATION(S)  
(35 U.S.C. Section 119(e))**

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below:

**PROVISIONAL APPLICATION NUMBER**

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**FILING DATE**

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**CLAIM FOR BENEFIT OF EARLIER U.S./PCT APPLICATION(S)  
UNDER 35 U.S.C. SECTION 120**

- ☐ The claim for the benefit of any such applications are set forth in the attached  
ADDED PAGES TO COMBINED DECLARATION AND POWER OF ATTORNEY  
FOR DIVISIONAL, CONTINUATION OR CONTINUATION-IN-PART (C-I-P)  
APPLICATION.



**ALL FOREIGN APPLICATION(S), IF ANY, FILED MORE THAN 12 MONTHS  
(6 MONTHS FOR DESIGN) PRIOR TO THIS U.S. APPLICATION**

NOTE: If the application filed more than 12 months from the filing date of this application is a PCT filing forming the basis for this application entering the United States as (1) the national stage, or (2) a continuation, divisional, or continuation-in-part, then also complete ADDED PAGES TO COMBINED DECLARATION AND POWER OF ATTORNEY FOR DIVISIONAL, CONTINUATION OR C-I-P APPLICATION for benefit of the prior U.S. or PCT application(s) under 35 U.S.C. Section 120.

**POWER OF ATTORNEY**

I hereby appoint the following practitioner(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

*(list name and registration number)*

JOSEPH H. HANDELMAN, 26179

RICHARD P. BERG, 28145

JOHN RICHARDS, 31053

JULIAN H. COHEN, 20302

RICHARD J. STREIT, 25765

WILLIAM R. EVANS, 25858

PETER D. GALLOWAY, 27885

JANET I. CORD, 33778

IAIN C. BAILLIE, 24090

CLIFFORD J. MASS, 30086

THOMAS F. PETERSON, 24790

CYNTHIA R. MILLER, 34678

*(Check the following item, if applicable)*

- ☐ I hereby appoint the practitioner(s) associated with the Customer Number provided below to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.
- ☐ Attached, as part of this declaration and power of attorney, is the authorization of the above-named practitioner(s) to accept and follow instructions from my representative(s).

NOTE: "Special care should be taken in continuation or divisional applications to ensure that any change of correspondence address in a prior application is reflected in the continuation or divisional application. For example, where a copy of the oath or declaration from the prior application is submitted for a continuation or divisional application filed under 37 CFR 1.53(b) and the copy of the oath or declaration from the prior application designates an old correspondence address, the Office may not recognize, in the continuation or divisional application, the change of correspondence address made during the prosecution of the prior application. Applicant is required to identify the change of correspondence address in the continuation or divisional application to ensure that communications from the Office are mailed to the current correspondence address. 37 CFR 1.63(d)(4)." Section 601.03, M.P.E.P., 7th Ed

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SEND CORRESPONDENCE TO

**Ladas & Parry**  
**26 West 61<sup>st</sup> Street**  
**New York, N.Y. 10023**

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DIRECT TELEPHONE CALLS TO:

*(Name and telephone number)*

**Julian H. Cohen**  
**(212) 708-1887**

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*(complete the following if applicable)*

Since this filing is a [ ] continuation [ ] divisional there is attached hereto a Change of Correspondence Address so that there will be no question as to where the PTO should direct all correspondence.

### DECLARATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

## SIGNATURE(S)

NOTE: Carefully indicate the family (or last) name, as it should appear on the filing receipt and all other document.

NOTE: Each inventor must be identified by full name, including the family name, and at least one given name without abbreviation together with any other given name or initial, and by his/her residence, post office address and country of citizenship. 37 C.F.R. Section 1.63(a)(3).

NOTE: Inventors may execute separate declarations/oaths provided each declaration/oath sets forth all the inventors. Section 1.63(a)(3) requires that a declaration/oath, inter alia, identify each inventor and prohibits the execution of separate declarations/oaths which each sets forth only the name of the executing inventor. 62 Fed. Reg. 53,131, 53,142, October 10, 1997.

### Full name of sole or first inventor

110 Hermann (Given Name) (Middle Initial or Name) DIEHL Family (Or Last Name)

Inventor's signature (X) [Signature]

Date (X) 26.3.01 Country of Citizenship Germany

Residence München, GERMANY DKX

Post Office Address Günderodestrasse 9, D-81827 München, GERMANY

### Full name of second joint inventor, if any

270 Willi (Given Name) (Middle Initial or Name) PLATZ Family (Or Last Name)

Inventor's signature (X) [Signature]

Date (X) 29.3.01 Country of Citizenship Germany

Residence München, GERMANY DKX

Post Office Address Gärtnerstrasse 30 D-80992 München, GERMANY

### Full name of third joint inventor, if any

300 Helmut (Given Name) (Middle Initial or Name) ZINNER Family (Or Last Name)

Inventor's signature (X) [Signature]

Date (X) 26.03.01 Country of Citizenship Germany

Residence Haar, GERMANY DKX

Post Office Address Dr. Machstrasse 35, D-85540 Haar, GERMANY

(check proper box(es) for any of the following added page(s)  
that form a part of this declaration)

☒ **Signature** for fourth and subsequent joint inventors. *Number of pages added* 1

\* \* \*

☐ **Signature** by administrator(trix), executor(trix) or legal representative for deceased or incapacitated inventor. *Number of pages added* \_\_\_\_\_

\* \* \*

☐ **Signature** for inventor who refuses to sign or cannot be reached by person authorized under 37 C.F.R. Section 1.47. *Number of pages added* \_\_\_\_\_

\* \* \*

☐ Added page for **signature** by one joint inventor on behalf of deceased inventor(s) where legal representative cannot be appointed in time. (37 C.F.R. Section 1.47)

\* \* \*

☐ Added pages to combined declaration and power of attorney for divisional, continuation, or continuation-in-part (C-I-P) application.

☐ Number of pages added \_\_\_\_\_

\* \* \*

☐ Authorization of practitioner(s) to accept and follow instructions from representative.

(If no further pages form a part of this Declaration,  
then end this Declaration with this page and check the following item)

☐ This declaration ends with this page.

**ADDED PAGE TO COMBINED DECLARATION AND POWER OF  
ATTORNEY FOR SIGNATURE BY FOURTH AND SUBSEQUENT INVENTORS**

Full name of fourth joint inventor, if any

Evelyne  GOTTZEIN  
(Given Name) (Middle Initial or Name) Family (Or Last Name)

Inventor's signature (X) Evelyne Gottzein

Date (X) 15.04.01 Country of Citizenship Germany

Residence Höhenkirchen GERMANY

Post Office Address Wirtsbreite 22, D-85635 Höhenkirchen GERMANY

Full name of fifth joint inventor, if any

(Given Name) (Middle Initial or Name) Family (Or Last Name)

Inventor's signature

Date  Country of Citizenship

Residence

Post Office Address

Full name of sixth joint inventor, if any

(Given Name) (Middle Initial or Name) Family (Or Last Name)

Inventor's signature

Date  Country of Citizenship

Residence

Post Office Address